

## **A Future Large-Aperture UVOIR Space Observatory: Reference Designs**



Norman Rioux

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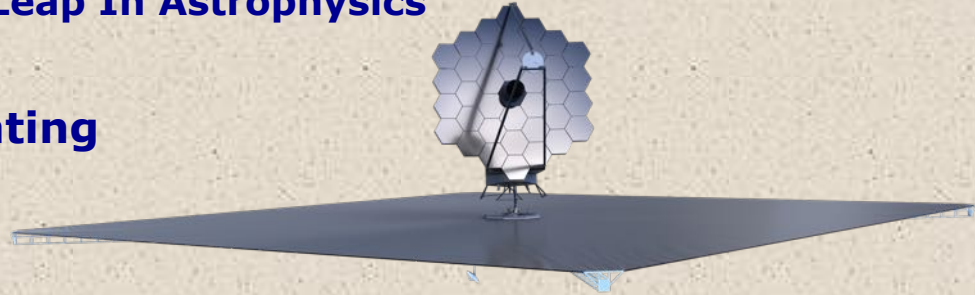
# Broad Consensus -

## Large Telescope Aperture Enables Breakthrough Science

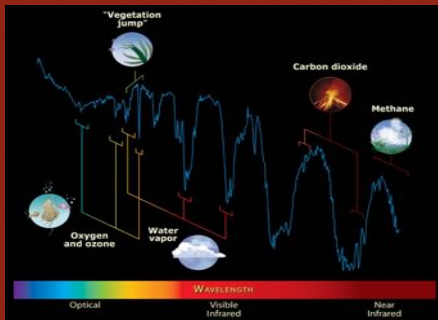
- ATLAST – Advanced Technology Large Aperture Space Telescope
  - Proposals submitted to 2010 NRC Decadal Survey
  - GSFC, MSFC, JPL, STScI
    - 8m monolith, 9.2m deployed, 16m deployed
  - 2010 Decadal Survey elevated technology investment for a mission to search for exo-Earths as its highest-priority “Medium Activity” for the decade
- LUVOIR – Large Ultraviolet Optical Infra-Red telescope
  - NASA’s 30-year vision for astrophysics
    - Enduring Quests, Daring Visions
    - Highlighted a Large UV/Optical/IR observatory as a priority mission for the 2020s.
- HDST – High Definition Space Telescope
  - Associated Universities for Research in Astronomy (AURA)
  - Report - From Cosmic Birth to Living Earth
  - Recommends large UVOIR telescope - [www.hdstvision.org/report/](http://www.hdstvision.org/report/)

# The Advanced Technology Large-Aperture Telescope (ATLAST) The Next Great Leap In Astrophysics

**A powerful, general-purpose  
non-cryogenic observatory operating  
from 0.1  $\mu\text{m}$  to 1.8+  $\mu\text{m}$ .**



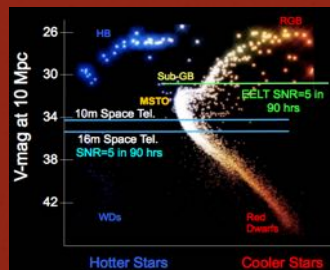
## Detection of Biosignatures in Habitable Zone Planets



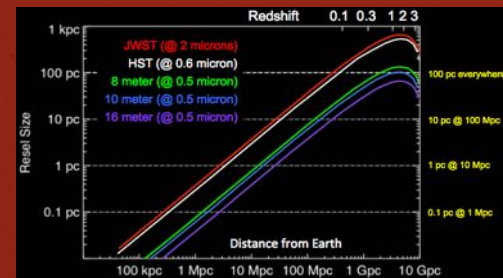
HST (2.4m)

15m Space Telescope

**Breakthrough in UVOIR Resolution and  
Sensitivity throughout the Universe**



**Tracing the History of Star  
Formation in all Types of Galaxies  
up to 10 Mpc**



**Resolve 100 pc Star-Forming Regions  
Everywhere in the Universe**



# ATLAST Telescope Parameter Table

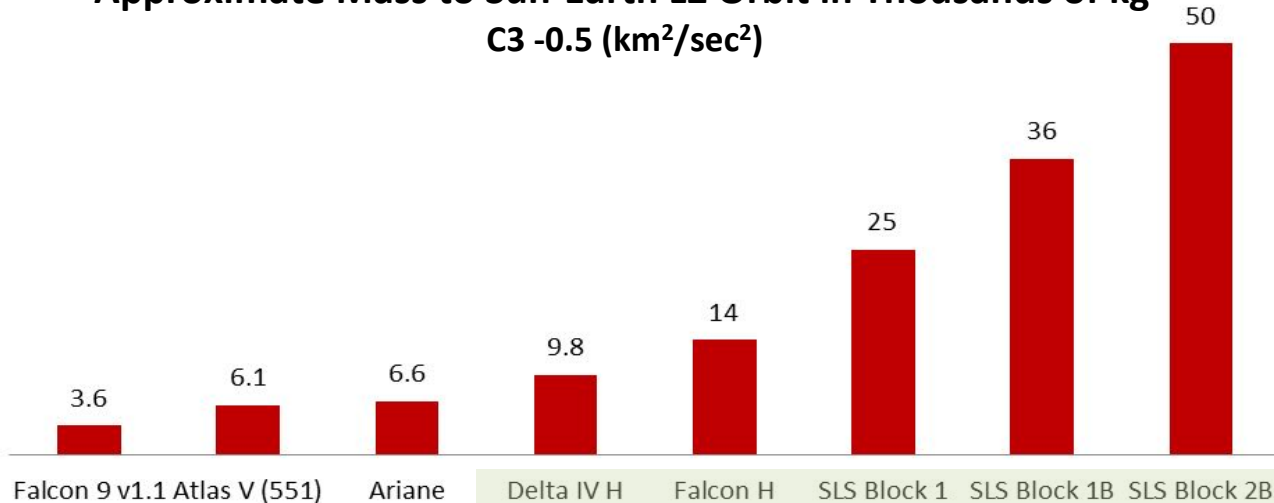
Parameter		Requirement	Stretch Goal	Traceability
Primary Mirror Aperture		≥ 8 meters	12 meters	Resolution, Sensitivity, Exoplanet Yield
Telescope Temperature		273 K – 293 K	-	Thermal Stability, Integration & Test, Contamination, IR Sensitivity
Wavelength Coverage	UV	100 nm– 300 nm	90 nm – 300 nm	
	Visible	300 nm – 950 nm	-	
	NIR	950 nm – 1.8 μm	950 nm – 2.5 μm	
	MIR	-	Sensitivity to 5.0 μm under evaluation	Transit Spectroscopy
Image Quality	UV	< 0.20 arcsec at 150 nm	-	
	Vis/NIR/MIR	Diffraction-limited at 500 nm	-	
Stray Light		Zodi-limited between 400 nm – 1.8 μm	Zodi-limited between 200 nm – 2.5 μm	Exoplanet Imaging & Spectroscopy SNR
Wavefront Error Stability		~ 10 pm RMS uncorrected system WFE per control step	-	Starlight Suppression via Internal Coronagraph
Pointing	Spacecraft	≤ 1 milli-arcsec	-	
	Coronagraph	< 0.4 milli-arcsec	-	

# ATLAST Instrument Parameter Table

Science Instrument	Parameter	Requirement	Stretch Goal
UV Multi-Object Spectrograph	Wavelength Range	100 nm – 300 nm	90 nm – 300 nm
	Field-of-View	1 – 2 arcmin	
	Spectral Resolution	R = 20,000 – 300,000 (selectable)	
Visible-NIR Imager	Wavelength Range	300 nm – 1.8 $\mu$ m	300 nm – 2.5 $\mu$ m
	Field-of-View	4 – 8 arcmin	
	Image Resolution	Nyquist sampled at 500 nm	
Visible-NIR Spectrograph	Wavelength Range	300 nm – 1.8 $\mu$ m	300 nm – 2.5 $\mu$ m
	Field-of-View	3 – 4 arcmin	
	Spectral Resolution	R = 100 – 10,000 (selectable)	
MIR Imager / Spectrograph	Wavelength Range		2.5 $\mu$ m – 8 $\mu$ m
	Field-of-View		3 – 4 arcmin
	Image Resolution		Nyquist sampled at 3 $\mu$ m
	Spectral Resolution		R = 5 – 500 (selectable)
Starlight Suppression System	Wavelength Range	400 nm – 1.8 $\mu$ m	200 nm – 2.5 $\mu$ m
	Raw Contrast	$1 \times 10^{-10}$	
	Contrast Stability	$1 \times 10^{-11}$ over integration	
	Inner-working angle	34 milli-arcsec @ 1 $\mu$ m	
	Outer-working angle	> 0.5 arcsec @ 1 $\mu$ m	
Multi-Band Exoplanet Imager	Field-of-View	~0.5 arcsec	
	Resolution	Nyquist sampled at 500 nm	
Exoplanet Spectrograph	Field-of-View	~0.5 arcsec	
	Resolution	R = 70 – 500 (selectable)	

# Launch Vehicle Capabilities

**Approximate Mass to Sun-Earth L2 Orbit in Thousands of kg**  
C3 -0.5 (km<sup>2</sup>/sec<sup>2</sup>)



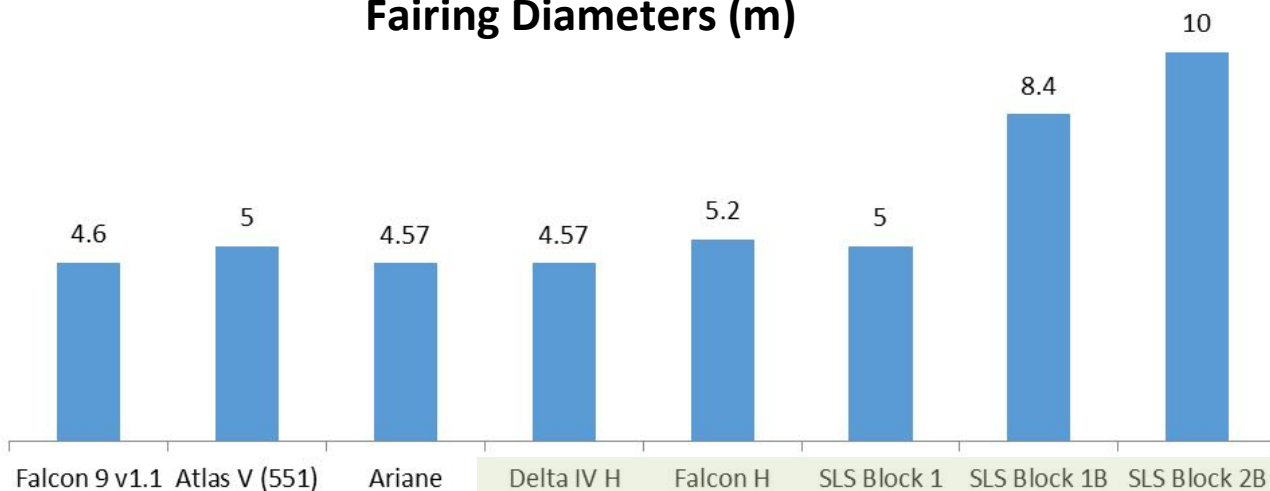
ATLAST is compatible with:

- Delta IV Heavy
- Falcon Heavy
- SLS

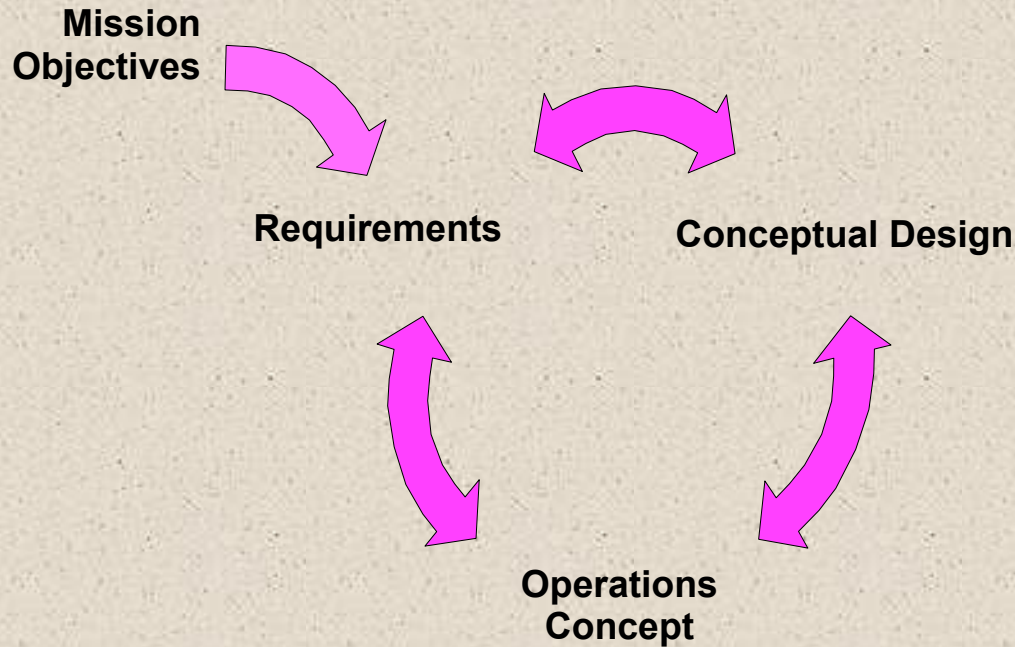
ATLAST and SLS engineer-to-engineer conceptual interface development meetings underway

Multiple vehicle candidates mitigate risks and associated costs

**Fairing Diameters (m)**



# ATLAST System Formulation



- Role of Conceptual Design
  - Derive and validate requirements
  - Enable balanced, cost effective, end to end system

# Engineering Design Reference Missions (EDRMs)

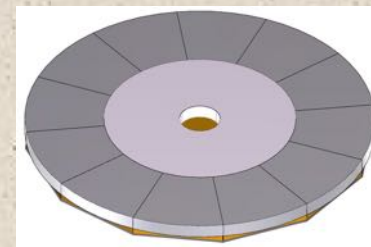
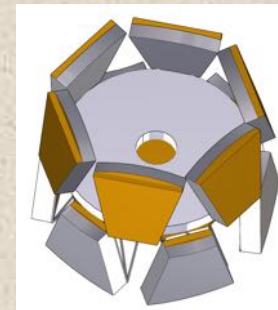
- Key design driver - Coronagraphy of exo-planets
- Multiple simultaneous science parameters
  - IWA, throughput, band pass, contrast, survey integration time, aperture, yield
  - WFE stability
    - Mechanical dynamics, jitter
    - Thermal stability
- Analyze engineering design trade space in depth and detail
  - Identify stressing requirements
  - Identify opportunities for margin against requirements
- Enable implementation trade studies to formulate most effective, well balanced, and lowest risk designs.



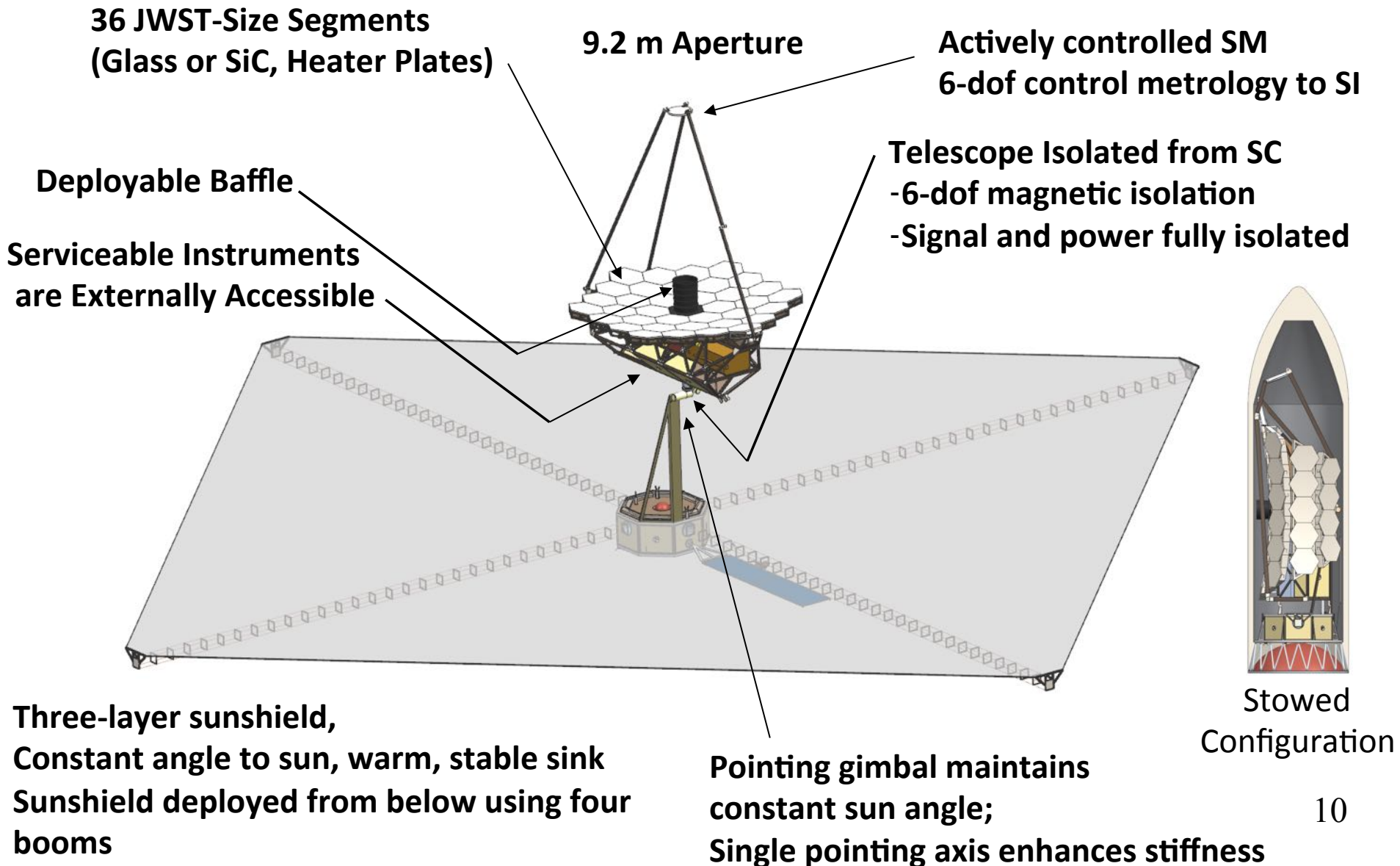
# SLS, Block II 10m Fairing Enabled EDRMs

Stahl et al., SLS - launched missions concept studies for LUVOIR Mission

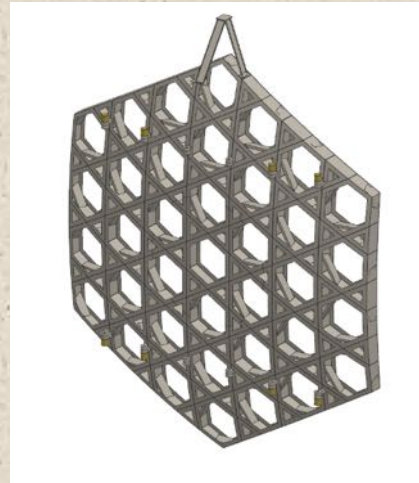
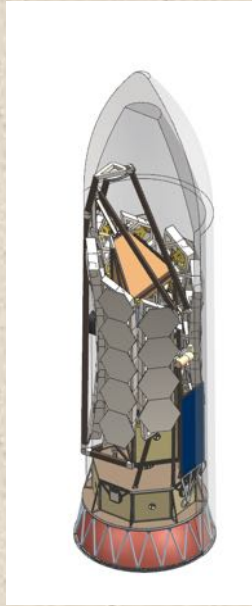
- 8-m monolith EDRM
  - Submitted to 2010 Decadal Survey
  - Largest possible monolith for space application
- 12.7 m deployed EDRM
  - Central monolith, deployed petals
  - Leverages depth in axis of primary mirror for mechanical stability



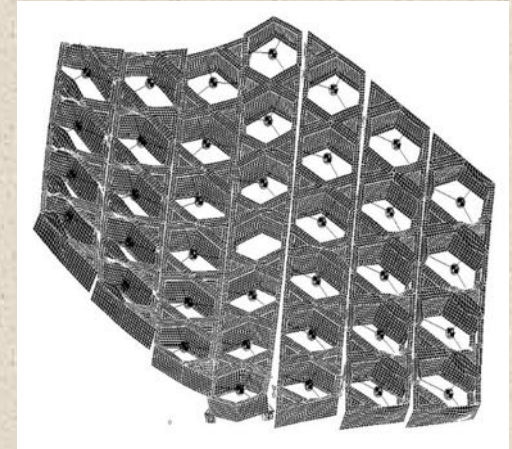
# Scalable Segmented EDRM



# Mechanical Dynamic Stability



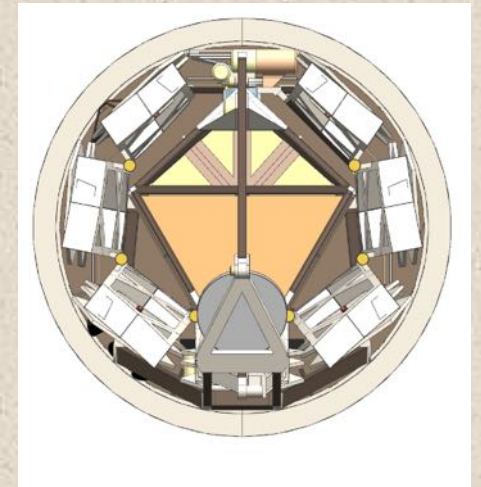
Backplane Design



Modal Analysis

5m fairing packaging

- 3 deployable mirror “wings” on each side of central strip
- Design for stiffness
- Iteration and optimization

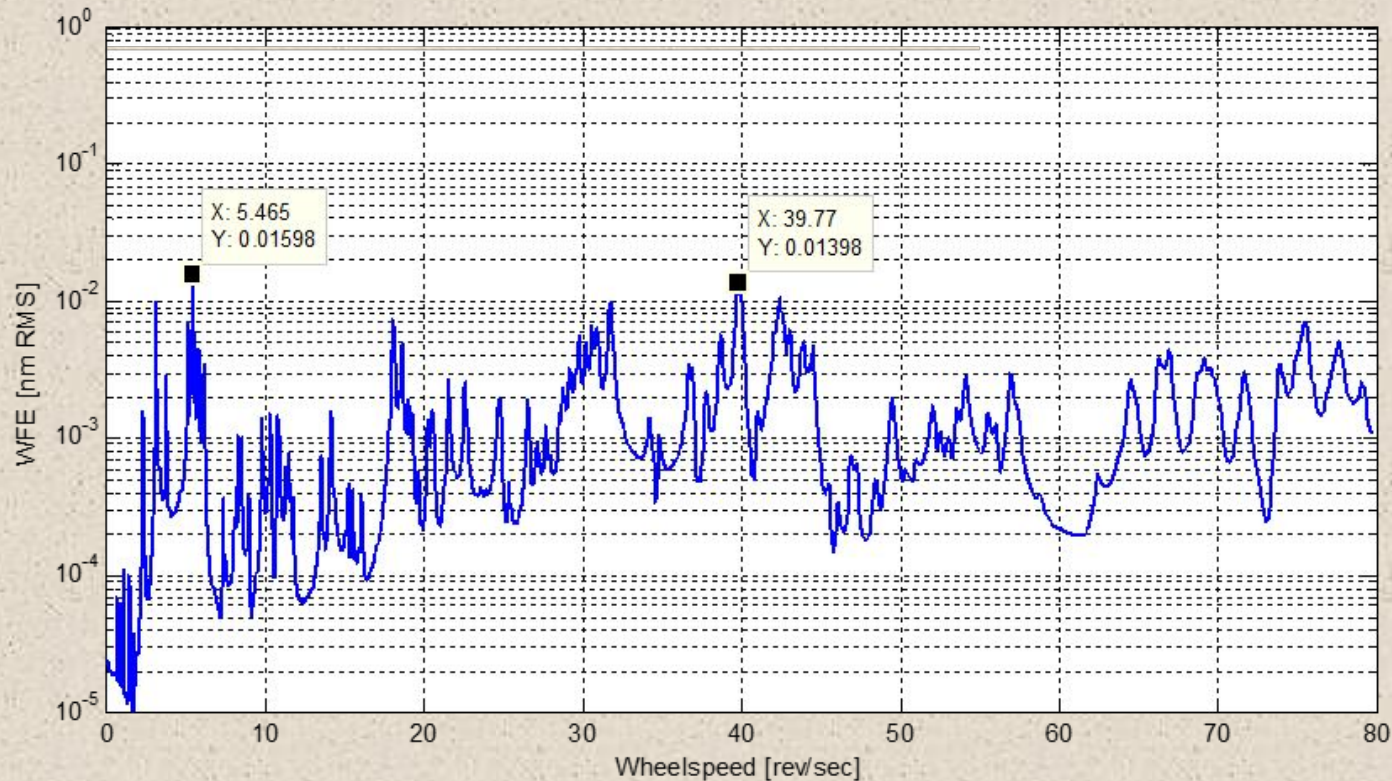


Axial View in Fairing



# Jitter Stability

- Initiation of integrated modelling process - preliminary analysis
- Single RWA worst case forcing function
- No model uncertainty factor (MUF)
- Includes model of contact-free isolation system – 4 decades of isolation

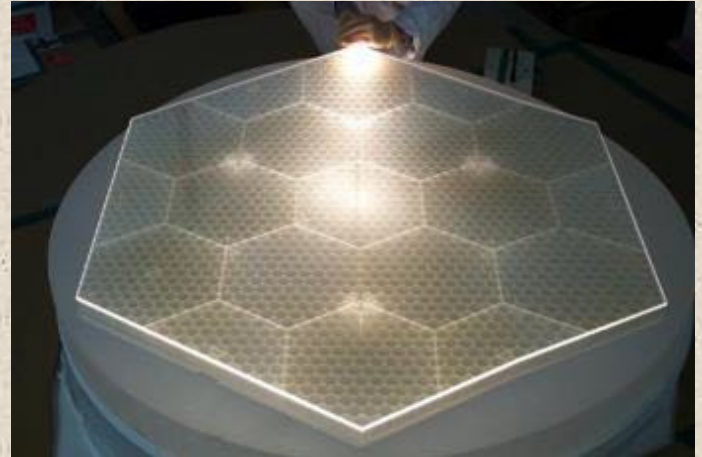


Future improvements - Include gimbal and telescope pointing boom, MUF



# Thermal Stability

- Preliminary analysis focused on feasibility of achieving picometer wave front error on individual mirror segment
- Eisenhower, Park, et al. “ATLAST ULE Mirror Segment Performance Analytical Predictions Based on Thermally Induced Distortions”
  - Analysis on a mirror segment with a high precision active heater control
- Initial results are encouraging
  - Future plans extend analysis to include the backplane



# Cost Control

- Fundamental mission priorities:
  - Deliver revolutionary science that unites the science community
  - Control cost and cost uncertainty
- Develop technologies early
  - Robust technology development plan already in place
    - Bolcar et al., Technology development for the Advanced Technology Large Aperture Space Telescope (ATLAST) as a candidate large UV-Optical-Infrared (LUVOIR) surveyor
  - Actively pursuing early funding for key technologies
- Non-cryogenic telescope
- Focus on TRL-9 implementations unless mission enabling

# Cost Control

- Scalable Segmented EDRM
  - Compatibility with multiple launch vehicles and fairing configurations
  - Departs from an extrapolation of previous segmented telescopes
    - Parallelization of telescope schedule
    - Economies of scale
    - High technology readiness, existing facilities and MGSE
    - Designs, hardware, mechanisms, personnel, ground support equipment, facilities, and experience with JWST



